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Spraying for Prevention of Apple Blotch and Apple Scab

F. H. Ballou and I. P. Lewis

OHIO
AGRICULTURAL EXPERIMENT STATION
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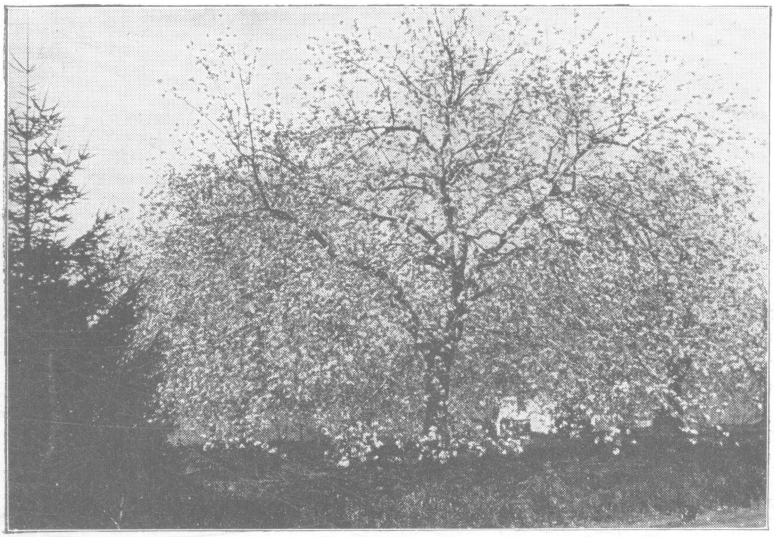


One of the fine old Rome Beauty apple trees at the Southeastern Test Farm, Carpenter, Ohio

A bountiful crop of sound Rome Beauty apples, in the spraying experiments for prevention of apple scab at the Southeastern Test Farm, Carpenter, Ohio

SPRAYING FOR PREVENTION OF APPLE BLOTCH AND APPLE SCAB

F. H. BALLOU AND I P LEWIS, Dept. of Horticulture

INTRODUCTION

In 1926 a five-year period of spraying experiments in prevention of apple blotch (*Phyllosticta solitaria*) and apple scab (*Venturia inaequalis*) was finished. The fundamental purpose was to determine the comparative merits of so-called "standard" bordeaux mixture (3-5-50 in Ohio in 1922) and the standard, or 1¼-50, commercial lime-sulfur solution, as fungicides in the prevention of disease of foliage and fruit of the apple.

The materials used were limited to copper, lime, and sulfur, the only spraying materials of recognized merit. It was hoped that something new and helpful might be learned from a further testing of these well-known materials in various proportions and combinations.

SOME NEW BORDEAUX FORMULAS

In the hope of lessening the danger of injury to foliage and fruit caused by the use of "standard" bordeaux, it was decided to use the same proportions of copper and lime in different dilute bordeaux sprays in comparison with the standard or more concentrated strength. The proportions are three parts by weight of high grade hydrated lime to one part of copper sulfate. Thus compounded the various bordeaux mixtures, 3-9-50, 2-6-50, 1-3-50, and ¾-2¼-50, contained different quantities, but always the same proportions, of copper and lime to each 50 gallons of water.

In addition to using these widely different strengths of bordeaux in competition with one another, they were compared with lime-sulfur sprays in controlling both apple blotch and apple scab. Both the commercial lime-sulfur solution and the commercial dry or powder form of the same compound were used in these tests.

STANDARD AND DILUTE SPRAYS IN APPLE BLOTCH PREVENTION

THE EXPERIMENTAL ORCHARD

For the experiments in the prevention of apple blotch a 20-year-old orchard of Ben Davis trees, situated on thin upland soil in Washington County, was selected. Due to extreme prevalence of blotch, this orchard had produced no salable and but

very little usable fruit for several years. The trees were lacking in vigor from scarcity of plant food materials in the soil, and were also badly infested by San Jose scale.

This orchard was divided into more than a dozen separate plots. Unless some contingency should necessitate a change, each was to be treated with the same spray formula thruout the five-year period of the test. This plan was found not entirely practicable, however, as each season brought requests to use new sprays or revised formulas of those with which we already were more or less familiar. It seemed advisable, therefore, to make several changes in plot treatments during the period of the tests; for the orchard area was limited and it was not possible to increase greatly the number of plots. Wherever a new spray was substituted for one that had been in use on a plot for one or more seasons, care was used to choose for the new formula a plot that had been receiving an impracticable or unpromising treatment. These changes of sprays on several plots account for the fact that some of the sprays were used for the full five years and others for shorter periods.

THE BASIC SPRAY

A basic or "all-over" spraying either with strong (1-8) commercial lime-sulfur solution or oil emulsion was given this orchard each spring, just as the buds were beginning to burst, for control of San Jose scale.

RULES FOR GRADING THE FRUIT

The different treatments of the various plots and the effect of those treatments as determined at the time of apple harvest are shown in Table 1. The results are given in percentages of fruit in each of the following classes:

Class No. 1—Free from blotch.—The apples of this class are without a trace of disease. A tiny mark of blotch, merely large enough to identify as blotch, places an apple in class No. 2.

Class No. 2—Very slightly blotched.—An apple in this class may bear a blotch as large as one-fourth of an inch in diameter; or two or more smaller blotch markings which, in the aggregate, would form a diseased area not larger than one-fourth of an inch in diameter. A blotch marking larger than the size indicated, either as a single blemish or an aggregate of smaller markings, disqualifies an apple for class No. 2 and places it in class No. 3. Obviously, therefore, the apples in class No. 2 compose a good grade of marketable fruit, as very many of the individual specimens bear but very minute evidence of blotch.

Class No. 3—Considerably blemished but not cracked by blotch.—This class includes all apples with blotch markings that disqualify the fruit for class No. 2, yet are not so serious as to cause bursting of the skins.

Class No. 4—Covered and cracked by blotch.—Includes all fruit so seriously diseased by blotch that it is rendered practically worthless.

THE APPLE BLOTCH SPRAYS

The treatment two weeks after petal-fall may be regarded as the first "blotch spray" of the season. Blotch spores have been known to issue from the disease-cankered twigs and shoots as early as two weeks after petal-fall. Usually, however, spore discharge begins three to four weeks after petal-fall and may continue for a considerable period of time.

Fig. 1.—Spraying for prevention of apple blotch in Washington County Test orchard

The spraying four weeks after petal-fall may be termed the *"special blotch application"* as it usually is the only *extra* spraying that is necessary to secure satisfactory control of blotch.

The spraying six weeks after petal-fall, while possibly of considerable benefit in seasons when the blotch spores are discharged over an unusually long period, in the experiments did not pay for the extra time and materials expended. As will be noted in Table 1, the two-, four-, and ten-week applications gave so nearly perfect control of blotch that a six-week spraying could not well improve the results.

It will be seen in the group of plot records embracing the so-called bordeaux formulas (Nos. 1, 2, 3, 4, 5, and 6) that lime-sulfur solution in each plot, was used for the open-calyx, or petal-fall, spraying. This was done in compliance with the still generally prevailing belief that the petal-fall application is the one most likely to cause russeting of the newly-set apples, and that it is safer to use lime-sulfur for this particular spraying. However, it was found that a great deal of russeting of apples was caused by the pre-bloom, or "pink", application.

The data from this group of plots indicate that there was little difference in the average percentage of blotch-free apples from the use of bordeaux formulas 3-9-50, 2-6-50, 1-3-50, and ¾-2¼-50. But these figures, alone, by no means tell the whole story; for the 3-9-50, or "standard" bordeaux, severely injured the foliage each season during the five-year period of the test, causing much yellowing and dropping of leaves. Moreover, the apples were considerably russeted each year, or the skins so roughened that the color

TABLE 1.—Results of Spraying for Prevention of Apple Blotch in Washington County

5 years, 1922—1926

No.	Treatment	Year	Wholly free from blotch Percent	Very slightly blotched Percent	Badly blemished by blotch Percent	Deformed or cracked by blotch Percent	Average of sound fruit for term of yrs. Percent
1	Bordeaux 3-9-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 3-9-50 in 2, 4, and 10 weeks	1922	98.4	1.5	0	0	99.5
		1923	99.1	0.8	0	0	
		1924	100	0	0	0	
		1925	100	0	0	0	
		1926	100	0	0	0	
2	Bordeaux 2-6-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 2-6-50 in 2, 4, 6, and 10 weeks	1922	96.7	2.7	0.3	0.1	99.2
		1923	99.5	0.4	0	0	
		1924	100	0	0	0	
		1925	100	0	0	0	
		1926	100	0	0	0	
3	Bordeaux 2-6-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 2-6-50 in 2, 4, 6, and 10 weeks	1922	98.5	1.2	0.1	0	99.6
		1923	100	0	0	0	
		1924	99.6	0.3	0	0	
		1925	100	0	0	0	
		1926	100	0	0	0	
4	Bordeaux 1-3-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 1-3-50 in 2, 4, and 10 weeks	1922	97.6	1.6	0.6	0	99.2
		1923	99.3	0.6	0	0	
		1924	100	0	0	0	
		1925	100	0	0	0	
		Not continued for 5th year					
5	Bordeaux ¾-2¼-50 in pink Lime-sulfur 1-40 in calyx Bordeaux ¾-2¼-50 in 2, 4, and 10 weeks	1922	94.1	4.9	0.8	0	98.6
		1923	99.5	0.3	0	0	
		1924	99.8	0.2	0.1	0	
		1925	100	0	0	0	
		1926	99.7	0.2	0	0	
6	Bordeaux 2-6-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 2-6-50 in 2, 4, 6, and 10 weeks (duplicate of Plot 3, running 3 years)	Not begun until 1923					100
		1923	100	0	0	0	
		1924	100	0	0	0	
		1925	100	0	0	0	
		Discontinued after 1925					
7	Bordeaux 2-6-50 in pink Lime-sulfur 1-40 in calyx, 2, 4, and 10 weeks	Not begun until 1923					97.8
		1923	95.7	2.1	2.1	0	
		1924	97.8	2.1	0	0	
		1925	97.7	1.6	0.5	0	
		1926	100	0	0	0	
8	Bordeaux 2-6-50 in pink Lime-sulfur 1-40 in calyx, 2, 4, 6, and 10 weeks	1922	96.6	2.9	0.3	0	98.8
		1923	97.8	2.1	0	0	
		1924	100	0	0	0	
		1925	99.7	0.2	0	0	
		1926	100	0	0	0	
9	Lime-sulfur 1-40 in pink Lime-sulfur 1-40 in calyx, 2, 4, and 10 weeks	1922	85.9	13.4	0.6	0	95.1
		1923	95.5	4.1	0.2	0	
		1924	99.0	0.9	0	0	
		1925	99.5	0.4	0	0	
		1926	95.9	4.0	0	0	

TABLE 1.—Results of Spraying for Prevention of Apple Blotch in Washington County—Continued

5 years, 1922—1926

No.	Treatment	Year	Wholly free from blotch	Very slightly blotched	Badly blemished by blotch	Covered and cracked by blotch	Average of sound fruit for term of yrs.
			Percent	Percent	Percent	Percent	Percent
			Not begun until 1923				
10	Lime-sulfur 1-40 in pink Lime-sulfur 1-40 in calyx, 2, 4, 6, and 10 weeks	1923 1924 1925	97.8 99.3 100	1.1 0.6 0	0 0 0	0 0 0	99.0
			Not used in 1926				
			Not begun until 1923				
11	Dry lime-sulfur 4-50 in pink Dry lime-sul. 3-50 in calyx, 2, 4, and 10 weeks	1923 1924 1925 1926	99.7 99.3 87.9 98.1	0.2 0.4 11.1 1.6	0.0 0.1 0.7 0.2	0 0 0.1 0	96.2
			Not begun until 1924				
12	Colloidal sulfur 5-50 in pink Colloidal sulfur 5-50 in calyx, 2, 4, and 10 weeks	1924 1925 1926	94.5 72.5 93.4	3.9 24.6 4.6	1.5 2.4 1.8	0 0.3 0	86.8
			Not begun until 1925				
13	Sulfocide 1 gal. to 200 in pink, calyx, 2, 4, and 10 weeks	1925 1926	96.3 97.4	2.3 2.2	0.4 0.2	0.9 0	96.8
			Not begun until 1926				
14	Wettable sulfur 2½-50 in pink, calyx, 2, 4, and 10 weeks	1926	93.6	5.5	0.8	0	93.6
			Not begun until 1924				
15	Hydrated lime 9-50 in pink, calyx, 2, 4, and 10 weeks	1924 1925 1926	96.5 79.5 80.7	1.9 17.5 12.7	1.4 2.4 5.6	0 0.5 0.8	85.5
			Not begun until 1925				
16	Hydrated lime and Kayso 9-1-50 in pink, calyx, 2, 4, and 10 weeks	1925 1926	90.1 83.9	9.2 12.5	0.5 2.2	0 1.2	87.0
17	Check plot—No spraying	1922 1923 1924 1925 1926	8.8 8.2 27.2 7.3 5.3	41.0 25.2 19.5 28.9 17.9	26.7 44.4 25.2 29.4 26.2	23.3 22 28.1 0.5 29.8	11.3

and finish of the fruit were seriously affected. In marked contrast, where the more dilute formulas were used, injury to foliage and fruit was proportionately less. There was very little evidence of such injury where the 1-3-50 or ¾-2¼-50 bordeaux formulas were applied.

Numbers 7 and 8 in Table 1 show results from the use of bordeaux mixture in the pink of the fruit buds, followed by lime-sulfur sprays during the remainder of the season. As might be expected, there was nothing gained by this program of treatment, for the bordeaux was used too early in the spring to exert any influence on blotch. Virtually, therefore, these two plots should be included with those sprayed thruout the season with lime-sulfur solutions, so far as control of the blotch is concerned.

LIME-SULFUR SPRAY CONTROLLED APPLE BLOTCH

In numbers 9 and 10 may be seen the surprisingly high percentages of wholly blotch-free apples produced in the plots sprayed thruout each season with commercial lime-sulfur solution at the usual rate of dilution (1¼-50). The difference in control of blotch by the use of this lime-sulfur spray as compared with standard and dilute bordeaux mixtures, was so slight as to be of little or no consequence, as the given percentages of sound fruit grown on the two plots stand in evidence. But here, again, figures alone fall far short of portraying the really outstanding results in this comparison. For there was very little spray injury to foliage and fruit caused by the lime-sulfur compound during the whole period of the test, and the color and finish of the fruit were far superior to the color and finish of the apples produced by the plots sprayed with bordeaux mixture.

In No. 11 dry lime-sulfur (the powder form dissolved into solution for spraying) gave equally as effective control of blotch as the commercial liquid form. The dry lime-sulfur proved less likely to injure foliage and fruit than the commercial solution.

THREE NEWER SULFUR FUNGICIDES

In Nos. 12, 13, and 14 are shown records of a three-, two-, and one-year trial, respectively, of colloidal sulfur, "Sulfocide", and wettable sulfur when used in controlling apple blotch. At the beginning of the three-year period colloidal sulfur gave surprisingly good results. In the second year it was disappointing, the quality of the material being inferior. A much better brand was available the third season and gave very good control of blotch. Colloidal sulfur reaches the orchardist either in paste or semi-liquid form. The latter is far preferable, as the paste, if at all dried out, is very slow and difficult to reduce to a solution by adding water and stirring.

For two seasons "Sulfocide"—a very concentrated liquid solution as it comes from the factory—was used in spraying for apple blotch. Altho it was used in accordance with instructions from the manufacturer, there were slight burning of the edges of the apple leaves and considerable burning and blackening of the calyx lobes of the apples by this spray. The finish of the fruit, so far as high color and extreme glossiness were concerned, was extra fine.

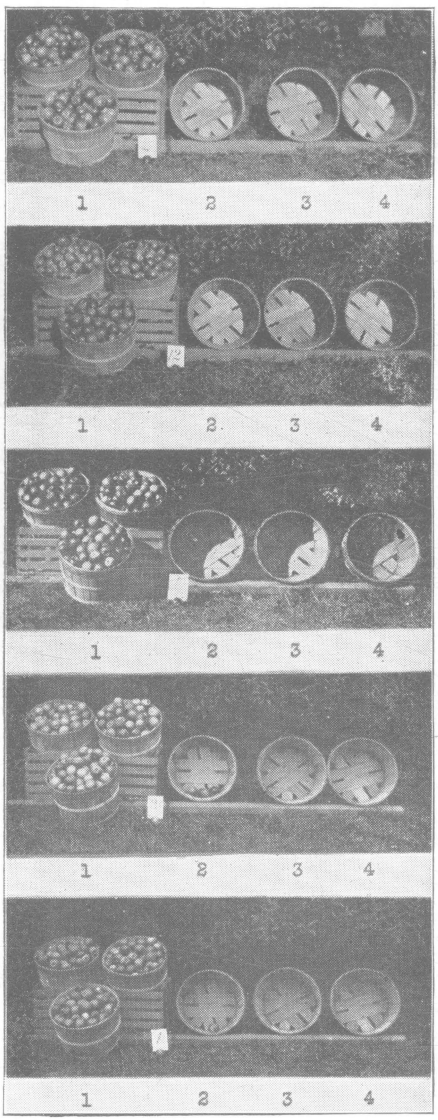
Wettable sulfur, unlike pure or raw sulfur, readily dissolves in water for convenience of spraying. The results of the use of this new form of sulfur combined with other material to cause it to combine with and remain in suspension in water, were rather good, for the one season of its use. Like "Sulfocide" wettable sulfur showed a tendency to burn the edges of the apple leaves and also to injure the calyx lobes of the fruit.

FUNGICIDAL EFFECTS OF LIME

At the very outset of this series of spraying experiments, the bordeaux formulas that carried heavy proportions of lime began to show evidence which led to the suspicion that the lime itself was exerting some fungicidal influence. So impressive were the plots of trees treated with the unusually dilute or weak bordeaux sprays, containing 75 percent of lime and 25 percent of copper sulfate, that it was determined to find room in the orchard for plots to be treated with lime sprays containing no copper. Perhaps such sprays might be termed "copperless bordeaux" as they contained the same quantity of lime, by weight, to each 50 gallons of water, as was being used in conjunction with copper sulfate in making the so-called "standard", or 3-9-50, bordeaux mixture.

The percentages of blotch-free apples from the plots sprayed with hydrated lime $Ca(OH)_2$, and arsenate of lead, and with lime, calcium caseinate "(Kayso)", and arsenate of lead, are rather surprising. The lime sprays, as the figures clearly indicate, gave practically the same degree of control of apple blotch as did colloidal sulfur. As a matter of fact the lime-treated plots indicated strongly that lime does exert a very helpful influence in the prevention of certain fungous diseases of foliage and fruits when used as a component part of bordeaux mixture.

It is not recommended that anyone adopt lime alone as a fungicidal spray; but it is suggested that lime in the future will come to be more largely used and appreciated—not merely to render strong and dangerous sprays safe, but for its fungicidal properties and its safety when used alone or in combination with other spray materials. The brightest, cleanest, and most luxuriant apple foliage in the test orchards in the autumn of 1926, was upon trees receiving the lime sprays.



SPRAY TREATMENT

Plot 1

Bordeaux 3-9-50 in pink
Lime-sulfur 1-40 in calyx
Bordeaux 3-9-50 in 2, 4, and 10 weeks

Plot 2

Bordeaux 2-6-50 in pink
Lime-sulfur 1-40 in calyx
Bordeaux 2-6-50 in 2, 4, and 10 weeks

Plot 3

Bordeaux 2-6-50 in pink
Lime-sulfur 1-40 in calyx
Bordeaux 2-6-50 in 2, 4, 6, and 10 weeks

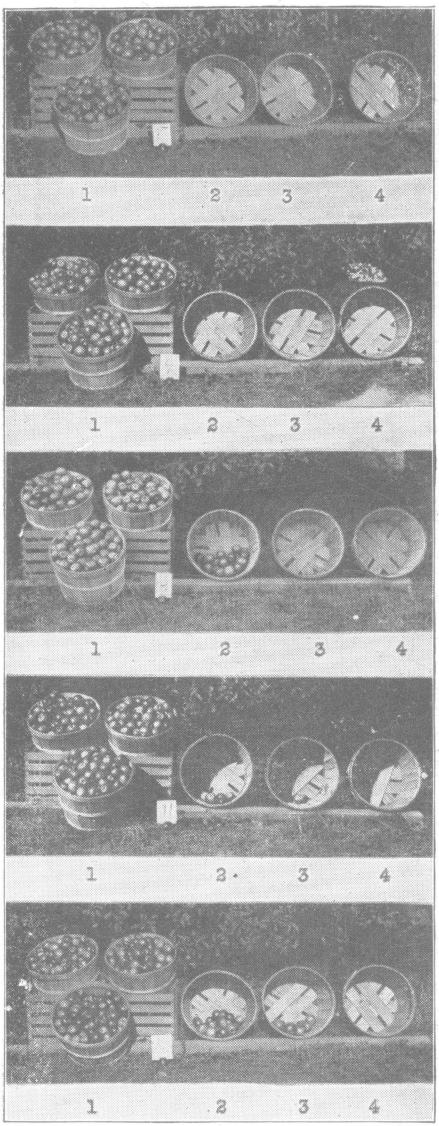
Plot 4

Bordeaux 1-3-50 in pink
Lime-sulfur 1-40 in calyx
Bordeaux 1-3-50 in 2, 4, and 10 weeks

Plot 5

Bordeaux ¾-2¼-50 in pink
Lime-sulfur 1-40 in calyx
Bordeaux ¾-2¼-50 in 2, 4, and 10 weeks

Fig. 2.—Ben Davis apples, 3 bushels (1 barrel) from each test plot, showing proportions of (1) fruit wholly free from blotch, (2) fruit very slightly blotched, (3) fruit considerably blemished by blotch, and (4) fruit badly infected (covered and cracked open) by blotch. The spray treatment of each plot of trees is stated at the right. See Table 1.



SPRAY TREATMENT

Plot 7

Bordeaux 2-6-50 in pink
Lime-sulfur 1-40 in calyx, 2, 4, and 10 weeks

Plot 8

Bordeaux 2-6-50 in pink
Lime-sulfur 1-40 in calyx, 2, 4, 6, and 10 weeks

Plot 9

Lime-sulfur 1-40 in pink, calyx, 2, 4, and 10 weeks

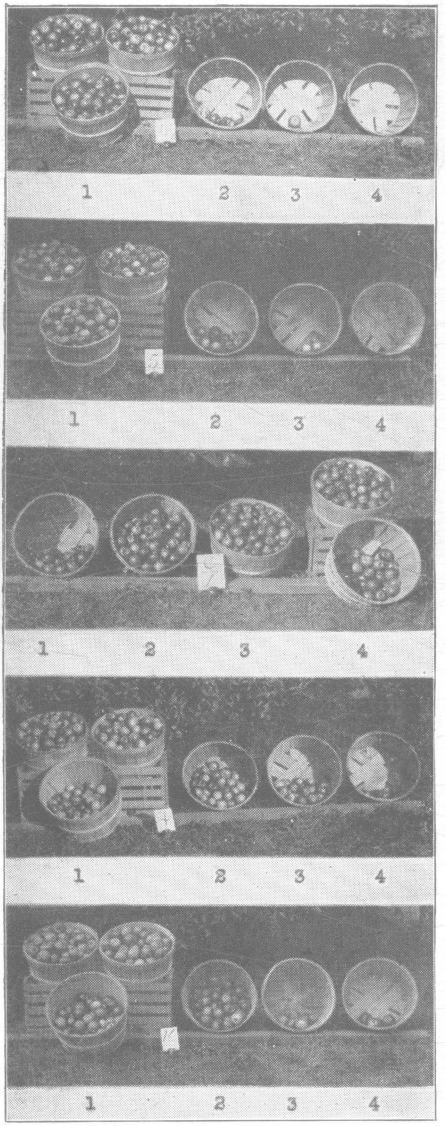
Plot 11

Dry lime-sulfur 4-50 in pink
Dry lime-sulfur 3-50 in calyx, 2, 4, and 10 weeks

Plot 12

Colloidal sulfur 5-50 in pink, calyx, 2, 4, and 10 weeks

Fig. 3.—Ben Davis apples, 3 bushels (1 barrel) from each test plot, showing proportions of (1) fruit wholly free from blotch, (2) fruit very slightly blotched, (3) fruit considerably blemished by blotch, and (4) fruit badly infected (covered and cracked open) by blotch. The spray treatment of each plot of trees is stated at the right. See Table 1.



SPRAY TREATMENT

Plot 13

Sulfocide 1-200 in pink, calyx, 2, 4, and 10 weeks

Plot 14

Wettable sulfur 2½-50 in pink, calyx, 2, 4, and 10 weeks

Plot 17

Check plot—No spraying

Plot 15

Hydrated lime 9-50 in pink, calyx, 2, 4, and 10 weeks

Plot 16

Hydrated lime and Kayso 9-1-50 in pink, calyx, 2, 4, and 10 weeks

Fig. 4.—Ben Davis apples, 3 bushels (1 barrel) from each test plot, showing proportions of (1) fruit wholly free from blotch, (2) fruit very slightly blotched, (3) fruit considerably blemished by blotch, and (4) fruit badly infected (covered and cracked open) by blotch. The spray treatment of each plot of trees is stated at the right. See Table 1.

SPRAYING FOR PREVENTION OF APPLE SCAB IN SOUTHEASTERN OHIO

THE EXPERIMENTAL ORCHARD

Experiments in prevention of apple scab by spraying, as did those for control of apple blotch, began in the spring of 1922 and closed with the season of 1926. An orchard of Rome Beauty trees about 30 years of age was chosen for this work at Carpenter, Meigs County, 30 or 40 miles from the one in Washington County. Both the foliage and fruit of the Carpenter orchard had been seriously affected by scab for a number of years. The severity of infection at the outset of this project may be judged from the fact that the "check", or unsprayed trees, for the first three years of the experiment, averaged but six-tenths of 1 percent of scab-free fruit per year.

BORDEAUX AND LIME-SULFUR COMPARED

The fundamental object in beginning this experiment was to make a careful and critical comparison of standard bordeaux mixture and lime-sulfur sprays in control of apple scab. At the outset, the orchard was divided into comparatively few plots. But the results obtained from the various formulas of dilute bordeaux mixture in the first year of blotch-control work in Washington County, induced us to include dilute sprays in the scab prevention tests in this old Rome Beauty orchard at Carpenter. Therefore, in the second season (1923) the larger plots were subdivided, obtaining thereby more than 20 smaller ones which, nevertheless, were of sufficient size and were adapted to the proposed experiments.

A blanket, or uniform, application of either strong (1-8) commercial lime-sulfur solution or oil emulsion was given the Carpenter orchard early each spring to insure the trees' remaining free from San Jose scale. This yearly "all-over" dormant or delayed dormant treatment included the check plots as well as all others in the orchard.

RULES FOR GRADING THE FRUIT

Table 2 shows the treatments of the plots and also the results noted at the time of harvest. These results are given in percentages of fruit in each class.

Class No. 1—Free from scab.—The apples in this class are required to be entirely free from scab.

Class No. 2—Very slightly scabbed.—An apple in this class may bear a scab as large as one-fourth of an inch in diameter; or two or more smaller scab markings which, in the aggregate, may

compose a diseased area not in excess of one-fourth inch in diameter. It is clear, therefore, that the apples in class No. 2 compose a good grade of marketable fruit, as many of the individual specimens bear but very minute evidences of scab.

Class No. 3—Considerably blemished, but not deformed, by scab.—This class includes all apples whose scab markings disqualify the fruit for class No. 2, yet whose blemishes are not so serious as to cause deformity of the fruit.

TABLE 2.—Results of Spraying for Prevention of Apple Scab in Meigs County

5 years, 1922—1926

No.	Treatment	Year	Wholly free from scab	Very slightly scabbed	Blemished by scab	Deformed by scab	Average of sound fruit for term of years
			Percent	Percent	Percent	Percent	Percent
1	Bordeaux 3-9-50, pink Bordeaux 1-3-50, calyx Bordeaux 1-3-50 in 2 and 10 weeks	.....	Not used until 1923				
		1923	82.4	6.1	9.2	2.0	72.7
		1924	59.5	17.9	18.3	4.1	
		1925	76.2	5.9	13.8	3.9	
		.....	Not continued in 1926				
2	Bordeaux 3-9-50, pink Bordeaux ¾-2¼-50, calyx Bordeaux ¾-2¼-50 in 2 and 10 weeks	.....	Not used until 1923				
		1923	86.6	5.1	7.0	1.2	89.4
		1924	86.3	9.8	3.2	0.5	
		1925	89.8	3.3	5.7	1.0	
		1926	95.1	4.3	0.5	0	
3	Bordeaux 2-6-50, pink Bordeaux ¾-2¼-50, calyx Bordeaux ¾-2¼-50 in 2 and 10 weeks	.....	Not used until 1923				
		1923	79.4	9.3	9.5	1.6	78.8
		1924	61.0	14.2	20.5	5.3	
		1925	81.1	6.4	10.3	2.1	
		1926	93.9	3.3	2.7	0	
4	Bordeaux 1-5-50, pink Bordeaux 1-5-50, calyx Bordeaux 1-5-50 in 2 and 10 weeks	.....	Not used until 1923				
		1923	84.6	3.8	9.8	1.6	89.4
		1924	83.7	6.4	7.0	2.7	
		1926	93.4	4.1	2.4	0	
		1926	96.1	3.0	0.7	0	
5	Bordeaux 1-5-50, pink Bordeaux ½-2½-50, calyx Bordeaux ½-2½-50 in 2 and 10 weeks		Not used until 1923				
		1923	84.4	5.3	9.4	0.7	88.9
		1924	77.2	15.7	6.3	0.6	
		1925	95.3	1.6	2.6	0.3	
		1926	98.8	1.2	0	0	
6	Bordeaux 3-9-50, pink Lime-sulfur 1-40, calyx Bordeaux 3-9-50 in 2 and 10 weeks	1922	55.6	14.9	23.4	6.1	83.9
		1923	81.3	5.4	8.9	3.7	
		1924	95.0	1.1	3.8	0	
		1925	94.4	2.3	1.8	1.3	
		1926	93.6	3.5	2.8	0	
7	Bordeaux 3-5-50, pink Lime-sulfur 1-40, calyx Bordeaux 3-5-50 in 2 and 10 weeks	.....	Used only in 1923 and 1924				
		1923	86.0	5.5	5.4	2.9	87.3
		1924	88.7	4.3	6.2	0.6	
		.....					
		.....					
8	Bordeaux 3-9-50, pink Lime-sulfur 1-40, calyx Bordeaux 1-3-50 in 2 and 10 weeks	.....	Not used until 1923				
		1923	91.3	4.2	3.9	0.4	92.0
		1924	88.4	7.1	2.7	1.6	
		1925	92.2	3.1	3.8	0.7	
		1926	96.3	2.0	1.5	0	
9	Bordeaux 2-6-50, pink Lime-sulfur 1-40, calyx Bordeaux 2-6-50 in 2 and 10 weeks	.....	Not used until 1925				
		.....					
		.....					
		1925	95.7	3.1	0.8	0.2	95.1
		1926	94.6	2.2	3.0	0	

TABLE 2.—Results of Spraying for Prevention of Apple Scab in Meigs County—Continued

5 years, 1922—1926

No.	Treatment	Year	Wholly free from scab	Very slightly scabbed	Blemished by scab	Deformed by scab	Average of sound fruit for term of years
			Percent	Percent	Percent	Percent	Percent
10	Bordeaux 2-6-50, pink Lime-sulfur 1-40, calyx Bordeaux 1-3-50 in 2 and 10 weeks	.... 1925	Used only in 1925 91.5	 5.3	 2.4	 0.6	 91.5
11	Bordeaux 2-6-50, pink Lime-sulfur 1-40, calyx Bordeaux ¾-2¾-50 in 2 and 10 weeks	..... 1923 1924	Used only in 1923 and 1924 80.2 81.7 	 12.8 13.8 	 5.0 4.1 	 1.8 0.3 	 80.9
12	Bordeaux 1-3-50, pink Lime-sulfur 1-40, calyx Bordeaux 1-3-50 in 2 and 10 weeks	 1926	Used only in 1926 97.2	 2.7	 0	 0	 97.2
13	Bordeaux 3-9-50, pink Lime-sulfur 1-40, calyx No 2-weeks spray Bordeaux 3-9-50 in 10 weeks	..... 1923 1924 1925 1926	Not used until 1923 98.1 95.6 89.4 99.4	 1.8 3.4 9.2 0	 0 0.8 1.3 0.5	 0 0 0 0	 95.6
14	Bordeaux 3-9-50, pink Hydrated lime 9-50, calyx, 2, and 10 weeks	..... 1923 1924	Used only in 1923 and 1924 71.7 67.2 	 17.1 18.6 	 8.7 9.3 	 2.1 4.7 	 69.4
15	Lime-sulfur sol. 1-25, pink Lime-sulfur sol. 1-40, calyx, 2, and 10 weeks	1922 1923 1924 1925	57.5 93.9 88.3 99.3 Not continued in 1926	15.6 3.9 4.7 0.6	21.1 1.5 5.9 0	5.5 0.5 0.9 0	84.7
16	Lime-sulfur sol. 1-40, pink Lime-sulfur sol. 1-40, calyx, 2, and 10 weeks	1922 1923 1924 1925 1926	71.9 92.4 98.0 97.5 100	9.8 1.8 1.9 1.4 0	13.0 5.1 0 0.9 0	5.3 0.5 0 0 0	91.9
17	Lime-sulfur sol. 1-40, pink Lime-sulfur sol. 1-80, calyx, 2, and 10 weeks	.... 1925 1926	Not used until 1925 97.0 96.9	 1.3 0.5	 1.4 2.5	 0.1 0	 96.9
18	Lime-sulfur sol. 1-40, pink Lime-sulfur sol. 1-40, calyx No 2-weeks spray Lime-sulfur sol. 1-40, 10 weeks	..... 1923 1924 1925 1926	Not used until 1923 96.2 92.1 98.1 99.0	 3.7 5.4 1.8 0	 0 2.4 0 0	 0 0 0 0	 96.3

Class No. 4—Deformed by scab.—Includes all apples so diseased by scab that they are misshapen or deformed.

BORDEAUX SPRAYS IN SCAB CONTROL

The results in percentages of different grades of apples from the use, exclusively, of bordeaux sprays of varying strengths are given in Nos. 1, 2, 3, 4, and 5 of Table 2. As in the cases of variously modified copper-lime sprays in blotch prevention, the results in

TABLE 2.—Results of Spraying for Prevention of Apple Scab in Meigs County—Concluded

5 years, 1922—1926

No.	Treatment	Year	Wholly free from scab	Very slightly scabbed	Blemished by scab	Deformed by scab	Average of sound fruit for term of years
			Percent	Percent	Percent	Percent	Percent
19	Lime-sulfur sol. 1-40, pink Hydrated lime 9-50, calyx Hydrated lime 9-50 in 2 and 10 weeks		Not used until 1925				92.7
		1925	88.3	8.0	2.7	0.8	
		1926	97.2	2.7	0	0	
20	Dry lime-sulfur 5-50, pink Dry lime-sulfur 4-50, calyx, 2, and 10 weeks		Not used in 1922 and 1926				91.1
		1923	90.2	3.8	4.3	1.6	
		1924	85.7	4 9	7.3	0.9	
		1925	97.5	0 9	0.9	0.4	
21	Dry lime-sulfur 4-50, pink Dry lime-sulfur 3-50, calyx, 2, and 10 weeks		Not used until 1925				96.5
		1925	97.2	1.4	0.9	0.2	
		1926	95.8	0.6	3.4	0	
22	Dry lime-sulfur 4-50, pink Dry lime-sulfur 2-50, calyx, 2, and 10 weeks		Not used until 1925				92.4
		1925	94.7	2 6	1.8	0.6	
		1926	90.2	1.1	6.3	2.2	
23	Dry lime-sulfur 5 50, pink Hydrated lime 9-50, calyx, 2, and 10 weeks		Not used in 1922 and 1926				69.3
		1923	78.2	9.8	9 9	1.9	
		1924	38.9	34.4	18 4	8.1	
		1925	90.8	8 0	1.2	0	
24	Colloidal sulfur 5-50, pink, calyx, 2, and 10 weeks		Not used until 1924				86.2
		1924	86.8	6 4	5.1	1.5	
		1925	74.6	9 5	12.2	3.5	
		1926	97.2	0.5	2.1	0	
25	Sulfocide 1-200, pink, calyx, 2, and 10 weeks		Not used until 1925				91.5
		1925	88.1	5 2	3.7	2.8	
		1926	94.9	0	5.0	0	
26	Wettable sulfur 2½-50, pink, calyx, 2, and 10 weeks		Not used until 1926				90.2
		1926	90.2	1.8	2.4	5.4	
27	Hydrated lime 9-50, pink, calyx, 2, and 10 weeks		Not used until 1923				62.4
		1923	47.1	19.7	26.0	7.0	
		1924	25.5	34.7	27.6	12.0	
		1925	83.5	10 7	3.3	2.3	
		1926	93.5	0.7	5 7	0	
28	Check plot No spraying						10
		1922	0	2.6	3.1	94.3	
		1923	1.8	13.6	64 5	19.9	
		1924	0	32 0	51.2	16.7	
		1925	2.5	36 6	45.7	15.0	
		1926	45.9	38.8	13.4	1.7	

disease-free apples were as nearly uniform as if treatment with a single formula had been used on all plots of this group. However, the more concentrated of these bordeaux formulas caused not only much foliage injury, but more or less russeting of fruit, because of the bordeaux being used in both the "pink" and the "petal-fall" spray applications.

In Nos. 6, 7, 8, 9, 10, 11, 12, and 13 are given records of scab control from the use of different formulas of bordeaux, in which the usual practice of spraying with lime-sulfur at the petal-fall period was observed. Here, too, the results in percentages of scab-free apples were as uniform as if all plots had been sprayed with the same mixture.

Fig. 5.—Two rows of Rome Beauty apple trees of equal age, size, and vigor. The row at the left sprayed with commercial lime-sulfur solution 1-40. The row at the right sprayed with standard, or 3-9-50, bordeaux mixture. Note the characteristic evidence of bordeaux injury to foliage on the upper hemisphere of trees at right—leaves yellow and dropping. The foliage of the lime-sulfur sprayed row is normal. Photograph taken in midsummer. See, also, Figure 6.

In Plot 13 the "2-weeks" spray was omitted in each of the four seasons over which the experiment extended, without any loss in percentage of scab-free apples. In case apple blotch were a factor, omission of the 2-weeks spray might prove disastrous especially in seasons in which blotch spores are discharged at an early date. Where scab alone is to be controlled, The results from this test indicate that little is to be gained from the application of a spray 2 weeks after the period of bloom. This evidence of the comparative unimportance of the 2-weeks application in these particular experiments must not be construed, however, into a recommendation of its omission.

No. 14 shows the results from the use of standard bordeaux in the first, or "pink", application of spray, followed the remainder of the season by only hydrated lime and arsenate of lead. It might appear that the seasonal average of 69.4 percent of perfectly sound fruit, in this case, was the direct result of the use of the 3-9-50 bordeaux mixture in the pre-blossom spraying. However, reference to No. 27 shows that the use of hydrated lime alone during the entire spraying period, gave 62.4 percent of wholly sound apples, or but 7 percent less of scab-free fruit as compared with standard bordeaux before and hydrated lime following the blooming period.

LIME-SULFUR SPRAYS IN SCAB CONTROL

In Nos. 15, 16, 17, and 18, just as in the earlier series of spraying tests of 1910-1914, commercial lime-sulfur solution applied at the usual rate of dilution (1¼-50), was even more effective in scab control than the so-called "standard" bordeaux mixture containing at least 3 pounds of copper sulfate to each 50 gallons of water. Moreover, while not entirely absent under certain unfavorable weather conditions, injury to foliage and fruit was much less where lime-sulfur sprays were employed.

Fig. 6.—The grass-mulch beneath apple trees shown in Fig. 5. Very few leaves were falling in midsummer from trees sprayed with lime-sulfur 1-40 (left). Many leaves were falling at that time from the trees sprayed with standard bordeaux 3-9-50 (right).

In No. 18 the results from the omission of the 2-weeks spray in a lime-sulfur spraying program may be noted. Just as was the case where the 2-weeks application was withheld from Plot 13 in the bordeaux program of treatment there was no loss from this omission, so far as sound, scab-free fruit was concerned. Presentation of this particular data is because of its novelty and interest.

In No. 19 the spray program was lime-sulfur 1-40 in the pink of the fruit buds, with nothing but hydrated lime and lead arsenate sprays used the remainder of the season. The high percentage of sound apples from this treatment possibly was due, in part at least, to the apparent fact that scab infection was waning to some extent as the end of the five-year period of spraying tests approached.

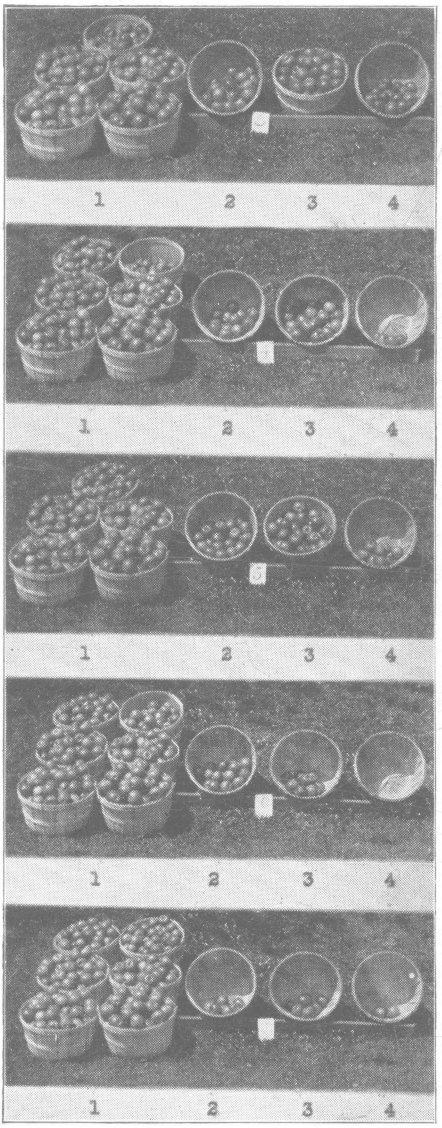
In Nos. 20, 21, and 22 may be found substantial evidence that dry lime-sulfur was no less effective in the prevention of apple scab than the commercial lime-sulfur solution and standard bordeaux mixture. Several years' experience indicates that sprays made from dry lime-sulfur are less likely to injure foliage and fruit of the apple than are sprays of commercial lime-sulfur solution.

No. 24 gives the results of three seasons' use of colloidal sulfur in combating apple scab. This is a pleasant and safe spray to apply, and in the closing season of the test gave considerably better results than did the first two lots used at Carpenter. Up to the present time it comes to the orchardist either in a paste or semi-liquid form, but a powder or dry form will be more desirable.

No. 25, "Sulfocide", gave good control of apple scab when used in connection with calcium caseinate, or "Kayso" (which the manufacturer explicitly advises when arsenate of lead is added to the spray). As in the blotch prevention work, this spray gave fruit of fine color and finish. It was used at the rate of 1 gallon of the very much concentrated liquid to 200 gallons of water. A little evidence of foliage injury was noted, and also slight burning of the calyx lobes of the apples, from its use in the old Rome Beauty orchard at Carpenter. An even greater degree of dilution than that recommended by the manufacturer might prove helpful in lessening danger of injury to foliage. It is a pleasant spray to apply and possesses a number of excellent qualities.

No. 26 wettable sulfur was given a trial as a spray for scab in the closing season of the test. The results were quite satisfactory. This spray material is composed principally of superfine sulfur to which is added a preparation which renders the sulfur easily combined with and held in suspension in water.

No. 27 presents clearcut evidence that high grade hydrated lime possessed some fungicidal value. The exceptionally good color and smooth, glossy finish of the apples sprayed with lime, were noted. However, the brands of lime usually found on the open market are quite variable in quality, and lime alone, especially if it be of an indifferent grade, is lacking in adhesiveness as compared with copper-lime and sulfur-lime combinations.



SPRAY TREATMENT

Plot 1

Bordeaux 3-9-50 in pink
Bordeaux 1-3-50 in calyx, 2, and 10 weeks

Plot 2

Bordeaux 3-9-50 in pink
Bordeaux ¾-2¼-50 in calyx, 2, and 10 weeks

Plot 3

Bordeaux 2-6-50 in pink
Bordeaux ¾-2¼-50 in calyx, 2, and 10 weeks

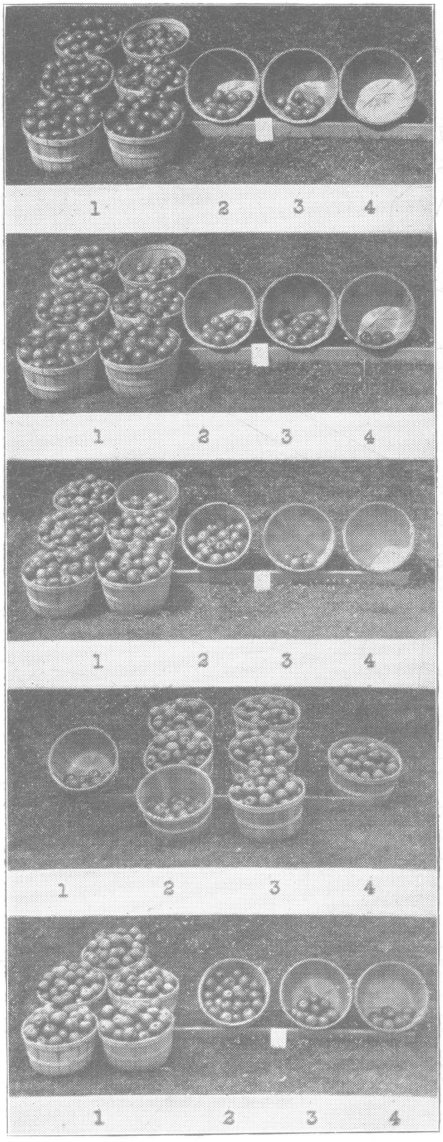
Plot 4

Bordeaux 1-5-50 in pink, calyx, 2, and 10 weeks

Plot 5

Bordeaux 1-5-50 in pink
Bordeaux ½-2½-50 in calyx, 2, and 10 weeks

Fig. 7.—Rome Beauty apples, 6 bushels (2 barrels) from each test plot, showing proportions of (1) fruit wholly free from scab, (2) fruit very slightly scabbed, (3) fruit considerably blemished by scab, and (4) fruit badly infected or deformed by scab.
The spray treatment of each plot of trees is stated at the right. See Table 2.



SPRAY TREATMENT

Plot 6

Bordeaux 3-9-50 in pink
Lime-sulfur 1-40 in calyx
Bordeaux 3-9-50 in 2 and 10 weeks

Plot 8

Bordeaux 3-9-50 in pink
Lime-sulfur 1-40 in calyx
Bordeaux 1-3-50 in 2 and 10 weeks

Plot 13

Bordeaux 3-9-50 in pink
Lime-sulfur 1-40 in calyx
2-weeks' spray omitted
Bordeaux 3-9-50 in 10 weeks

Plot 28

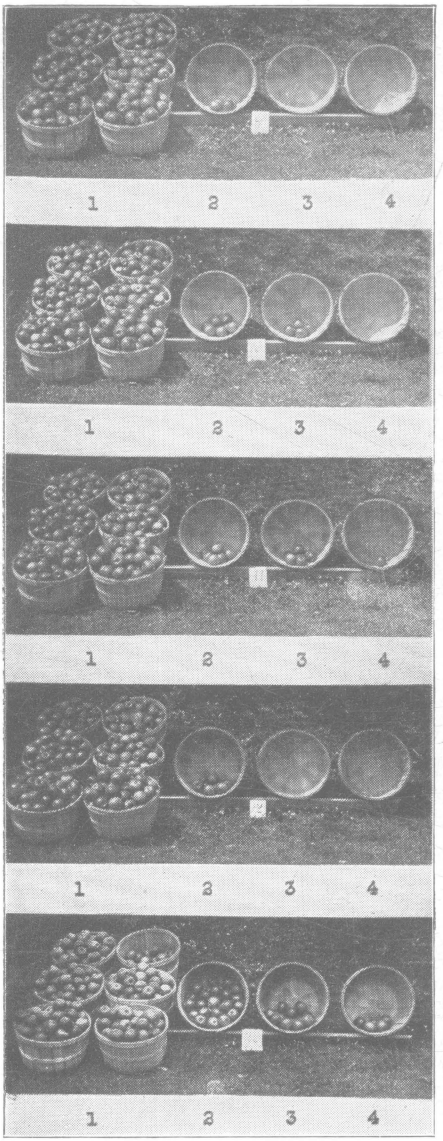
Check plot—No spraying

Plot 27

Hydrated lime 9-50 in pink, calyx, 2, and 10 weeks

(Results from the old Rome Beauty section of the Carpenter project in scab prevention).

Fig. 8.—Rome Beauty apples, 6 bushels (2 barrels) from each test plot, showing proportions of (1) fruit wholly free from scab, (2) fruit very slightly scabbed, (3) fruit considerably blemished by scab, and (4) fruit badly infected or deformed by scab.
The spray treatment of each plot of trees is stated at the right. See Table 2.



SPRAY TREATMENT

Plot 15

Lime-sulfur 1-25 in pink
Lime-sulfur 1-40 in calyx, 2, and 10 weeks

Plot 16

Lime-sulfur 1-40 in pink, calyx, 2, and 10 weeks

Plot 17

Lime-sulfur 1-40 in pink
Lime-sulfur 1-80 in calyx, 2, and 10 weeks

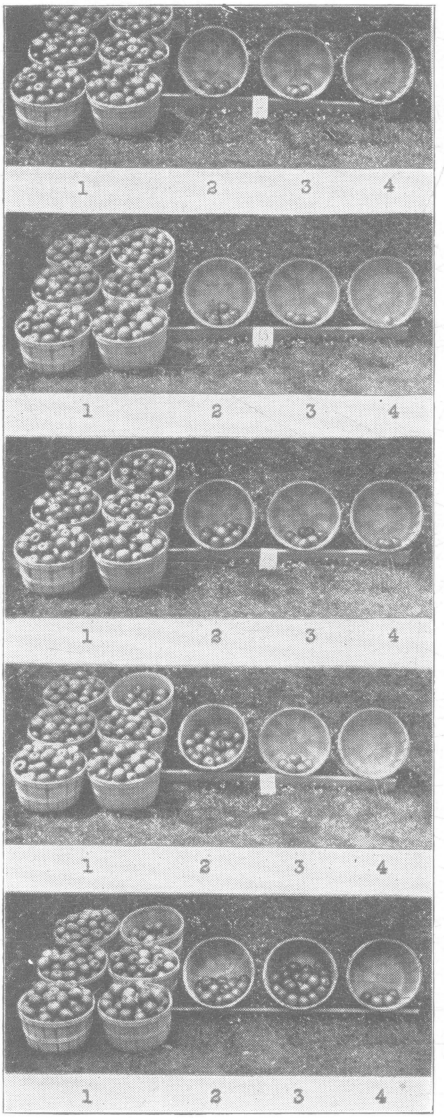
Plot 18

Lime-sulfur 1-40 in pink and calyx
2-weeks' spraying omitted
Lime-sulfur 1-40 in 10 weeks

Plot 19

Lime-sulfur 1-40 in pink
Hydrated lime 9-50 in calyx, 2, and 10 weeks

Fig. 9.—Rome Beauty apples, 6 bushels (2 barrels) from each test plot, showing proportions of (1) fruit wholly free from scab, (2) fruit very slightly scabbed, (3) fruit considerably blemished by scab, and (4) fruit badly infected or deformed by scab.
The spray treatment of each plot of trees is stated at the right. See Table 2.



SPRAY TREATMENT

Plot 20

Dry lime-sulfur 5-50 in pink
Dry lime-sulfur 4-50 in calyx, 2, and 10 weeks

Plot 21

Dry lime-sulfur 4-50 in pink
Dry lime-sulfur 3-50 in calyx, 2, and 10 weeks

Plot 22

Dry lime-sulfur 4-50 in pink
Dry lime-sulfur 2-50 in calyx, 2, and 10 weeks

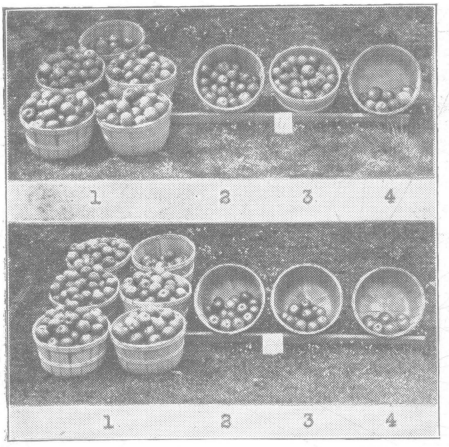
Plot 23

Dry lime-sulfur 5-50 in pink
Hydrated lime 9-50 in calyx, 2, and 10 weeks

Plot 27

Hydrated lime 9-50 in pink, calyx, 2, and 10 weeks

Fig. 10.—Rome Beauty apples, 6 bushels (2 barrels) from each test plot, showing proportions of (1) fruit wholly free from scab, (2) fruit very slightly scabbed, (3) fruit considerably blemished by scab, and (4) fruit badly infected or deformed by scab.
The spray treatment of each plot of trees is stated at the right. See Table 2.



SPRAY TREATMENT

Plot 24

Colloidal sulfur 5-50 in pink, calyx, 2, and 10 weeks

Plot 25

Sulfocide 1-200 in pink, calyx, 2, and 10 weeks

(Results from the young Rome Beauty section of the Carpenter project in scab prevention).

Fig. 11.—Rome Beauty apples, 6 bushels (2 barrels) from each test plot, showing proportions of (1) fruit wholly free from scab, (2) fruit very slightly scabbed, (3) fruit considerably blemished by scab, and (4) fruit badly infected or deformed by scab.
The spray treatment of each plot of trees is stated at the right. See Table 2.

ADDITIONAL EXPERIMENTS IN THE PREVENTION OF APPLE SCAB

Here and there in the old orchard of Rome Beauty apple trees used for spraying experiments at Carpenter, there were younger trees (replants), which probably ranged from 8 to 12 years of age at the beginning of this series of experiments in 1922. These younger trees are of the Rome and Ensee varieties, and came freely into fruiting in the years 1923, 1924, and 1925. Intermingled as they are among the large trees of the old orchard, they were sprayed at the same times and with the same spray solutions as the experimental plots in which they chanced to be growing. Records of percentages of sound and defective fruit of these younger trees were obtained.

In these later plantings "check", or untreated, trees were not left for comparison with those that were regularly sprayed, for the reason that the younger trees were situated under widely varying conditions among the older and larger ones. Some of the younger trees were favored by ample space and unobstructed sunlight. Others were standing between and were more or less crowded and shaded by older trees. Hence chances of exposure of the "replants"

to infection as well as opportunities for partial immunity from scab were as widely different as their situations among the old trees. The degree of infection by apple scab fungus in this orchard for the years 1923-1926 is indicated by the records of the "check", or untreated, trees in Table 2.

TABLE 3.—Spraying Young Rome Beauty Trees for Control of Apple Scab at Carpenter

4 years, 1923—1926

No.	Treatment	Year	Wholly free from scab	Very slightly scabbed	Blemished by scab	Deformed by scab	Average of sound fruit for term of years
			Percent	Percent	Percent	Percent	Percent
1	Bordeaux 3-9-50 in pink Bordeaux ¾-2¼-50 in calyx, 2, and 10 weeks	.... 1924 1925 1926	Not used until 1924 69.3 89.1 90.7	17.9 4.3 4.8	10.6 5.7 4.3	2.0 0.7 0	83.0
2	Bordeaux 2-6-50 in pink Bordeaux ¾-2¼-50 in calyx, 2, and 10 weeks	1923 1924 1925 1926	81.6 57.0 93.2 90.3	5.3 23.4 2.4 5.7	12.0 12.3 3.2 3.8	0.9 7.0 1.0 0	80.5
3	Bordeaux 3-9-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 1-3-50 in 2, and 10 weeks	1923 1924 1925 1926	92.2 86.3 95.2 99.5	2.7 8.4 1.8 0.4	3.4 3.2 2.5 0	1.5 1.9 0.3 0	93.3
4	Lime-sulfur 1-40 in pink, calyx, 2, and 10 weeks	1923 1924 1925 1926	95.3 99.2 97.9 99.4	1.6 0.7 1.5 0.5	2.1 0 0.5 0	0.8 0 0 0	97.9
5	Dry lime-sulfur 5-50 in pink Dry lime-sulfur 4-50 in calyx, 2, and 10 weeks	1923 1924 1925	90.3 87.9 95.0 Not continued in 1926	1.9 6.7 3.0	5.9 3.0 1.1	1.7 2.3 0.7	91.0
6	Dry lime-sulfur 4-50 in pink Dry lime-sulfur 3-50 in calyx, 2, and 10 weeks	.... 1925 1926	First full crop 1925 93.8 99.4	2.4 0.5	3.7 0	0 0	96.6
7	Dry lime-sulfur 4-50 in pink Dry lime-sulfur 2-50 in calyx, 2, and 10 weeks	.... 1925 1926	First full crop 1925 90.6 98.0	5.8 0.9	3.1 0.9	0.4 0	94.3
8	Colloidal sulfur 5-50 in pink, calyx, 2, and 10 weeks	.... 1925 1926	First full crop 1925 84.5 93.6	8.2 2.4	4.3 3.4	2.8 0.4	89.0
9	Sulfocide 1-200 in pink, calyx, 2, and 10 weeks	.... 1925 1926	First full crop 1925 92.8 96.9	2 3	3.5 0	1.5 0	94.8
10	Hydrated lime 9-50 in pink, calyx, 2, and 10 weeks	.... 1925 1926	First full crop 1925 90.1 89.5	4.2 8.6	4.6 1.8	0.9 0	89.8

RUSSETING OF A VARIETY EASILY SUSCEPTIBLE TO INJURY

The Ensee apple, generally supposed to be a seedling of Rome Beauty, is very subject to russeting, burning, and cracking of the skin of the fruit by action of copper sprays. Such injury was especially severe in 1925 at Carpenter, and special grading was done to determine the actual extent of this characteristic burning by use of bordeaux sprays. On the other hand, there was very little evidence of injury to the Ensee where sulfur sprays were employed.

TABLE 4.—Spraying Young Ensee Apple Trees for Control of Apple Scab, at Carpenter

4 years, 1923—1926

No.	Treatment	Year	Wholly free from scab	Very slightly scabbed	Blemished by scab	Deformed by scab	Average of sound fruit for term of years
			Percent	Percent	Percent	Percent	Percent
1	Bordeaux 3-9-50 in pink Bordeaux ¾-2¼-50 in calyx, 2, and 10 weeks	1923 1924 1925 1926	91.4 90.2 92.1 99.1	3.1 3.4 3.4 0.8	3.8 5.5 4.1 0	1.5 0.6 0.3 0	93.2
2	Bordeaux 3-9-50 in pink Bordeaux 1-3-50 in calyx, 2, and 10 weeks	1923 1924 1925 1926	Used only in 1924-25 96.7 93.2	 3 2 3.5 	 0 3.1 	 0 0 	94.9
3	Bordeaux 2-6-50 in pink Bordeaux ¾-2¼-50 in calyx, 2, and 10 weeks	1923 1924 1925 1926	87 0 86.6 69.0 99.4	4.9 7.7 7.7 0.5	6.8 5.9 18.0 0	1.1 0.7 5.1 0	85.5
4	Bordeaux 3-9-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 1-3-50 in 2 and 10 weeks	1923 1924 1925 1926	92.9 88 4 94.6 94.0	5.3 7.1 2.0 4.7	1.7 2.7 2.9 1.1	0 1.6 0.4 0	92.4
5	Lime-sulfur 1-40 in pink, calyx, 2, and 10 weeks	1923 1924 1925 1926	82.4 94.8 95.4 98.4	6.7 5.1 1.6 1.5	9.4 0.0 2.1 0	1.3 0 0.8 0	92.7
6	Dry lime-sulfur 5-50 in pink Dry lime-sulfur 4-50 in calyx, 2, and 10 weeks	1923 1924 1925 1926	87.4 95.3 96.5 97.2	5.7 3.1 1.4 0.9	5.6 1.5 1.4 1.8	1.0 0 0.5 0	94.1
7	Colloidal sulfur 5-50 in pink, calyx, 2, and 10 weeks	... 1924 1925 1926	Not used until 1924 88.2 92.6 99.0	 5.8 4.8 0.9	 3.6 1.6 0	 2.2 0.8 0	93.5
8	Hydrated lime 9-50 in pink, calyx, 2, and 10 weeks	1924 1925 1926	Not used until 1924 81.4 95.6 Not bearing in 1926	11.1 2.7	3.7 1.3	3 7 0.2	88.5

Copper sprays applied in the "pink" of the fruit buds, as shown on page 16, are as likely to cause russeting of apples as are the calyx or petal-fall applications. The generally prevailing belief has

been that, where a so-called bordeaux program of spraying is practiced, the substitution of lime-sulfur for bordeaux in the petal-fall application effectively prevents russeting. This was not found to be wholly tenable, as the figures in Table 4 clearly indicate. It is true that the substitution of lime-sulfur for bordeaux in the petal-fall spraying will assist in lessening the danger of russeting; but, in many cases, considerable injury to the fruit is done by bordeaux in the pre-bloom treatment, which the lime-sulfur cannot overcome in the petal-fall spraying.

TABLE 5.—Russeting of Ensee Apple at Carpenter in 1925

No.	Treatment	Sufficiently clear of russeting to be marketable in the "A", or first, grade Percent	Russeted to the extent that the fruit was unmarketable in "A" grade Percent
1	Bordeaux 3-9-50 in pink Bordeaux 1-3-50 in calyx, 2, and 10 weeks	5.6	94.4
2	Bordeaux 3-9-50 in pink Bordeaux ¾-2¼-50 in calyx, 2, and 10 weeks	11.0	89.0
3	Bordeaux 2-6-50 in pink Bordeaux ¾-2¼-50 in calyx, 2, and 10 weeks	4.6	95.4
4	Bordeaux 3-9-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 1-3-50 in 2 and 10 weeks	27.0	73.0
5	Bordeaux 2-6-50 in pink Lime-sulfur 1-40 in calyx Bordeaux 1-3-50 in 2 and 10 weeks	17.2	82.8
6	Lime-sulfur 1-40 in pink, calyx, 2, and 10 weeks	98.0	2.0
7	Dry lime-sulfur 5-50 in pink Dry lime-sulfur 4-50 in calyx, 2, and 10 weeks	94.0	6.0
8	Colloidal sulfur 5-50 in pink, calyx, 2, and 10 weeks	98.7	1.3
9	Hydrated lime 9-50 in pink, calyx, 2, and 10 weeks	96 0	4.0

In Nos. 1, 2, and 3 in Table 4, are shown the very small percentages (5, 6, 11, and 4.6 percent) of fruit free from russeting where bordeaux of different and very dilute formulas was used thruout the spraying period. In Nos. 4 and 5 it may be seen that the substitution of lime-sulfur for dilute bordeaux mixture in the petal-fall sprayings increased the percentages of clear fruit to some extent, but by no means served as an effectual preventive of russeting. Only 27 and 17.2 percent of clear fruit resulted from this substitution. But in Nos. 6 and 7, where lime-sulfur sprays were used in *both the pre-bloom and after-bloom sprays*, the percentages of clear or unrusseted fruit were 98 and 94 percent.

SUMMARY AND SUGGESTIONS FOR THE ORCHARDIST

THORONESS OF FIRST IMPORTANCE IN SPRAYING

The most important lesson from these spraying experiments is the unvarying substantial evidence that THORONESS in application of sprays is the one factor that, above all others, determines success or failure in combating fungous diseases in the apple orchard. "Thoroness" does not mean excessive or wasteful use of valuable spraying materials, but generous, careful, timely treatment of the trees.

LIME-SULFUR SPRAYS EFFECTIVE FUNGICIDES

Of next importance, perhaps, among results of the work just completed, is the evidence that the lime-sulfur spray is an effective fungicide, equal in a number of respects and superior in others to the bordeaux mixture, for the prevention of apple scab and apple blotch. This evidence of the excellence of lime-sulfur spray as compared with bordeaux is practically the same as that obtained in a similar five-year period of spraying experiments conducted by the horticultural department during the years 1910 to 1914, inclusive.

DRY LIME-SULFUR BOTH EFFECTIVE AND SAFE

An additional feature of these newer tests is the evidence that commercial dry or powdered lime-sulfur, as now produced, not only equals the commercial liquid form as a fungicide, but possesses the additional advantage of being less likely to injure apple foliage and fruit when applied as a spray in hot weather. The season of 1926 was rather notable in many sections of Ohio for injury to the foliage and fruit of the apple by the liquid lime-sulfur spray applied in the usual proportions of 1 to 40. But in comparison no such injury was caused by the dry or powdered form of lime-sulfur at the strength of 3 pounds to 50 gallons of water in these experiments. Perhaps it should be made clear that dry lime-sulfur, which is dissolved in water and used as a spray, is different from Soluble Sulfur; and, likewise that it is distinct from superfine sulfur used for dusting orchards.

Another point brought out in comparing commercial liquid lime-sulfur with the dry form in certain seasons was a peculiar affection of the apple foliage immediately following the unfolding of the leaf-clusters and the first appearance of the bud clusters. This stage of development of the fruit buds is the signal for the first, and one of the more important, applications of fungicidal spray for

prevention of apple scab. Liquid lime-sulfur (1 to 40) spray in occasional years caused not only a distinct check to foliage development, but a crimping and dwarfing effect on the newly opened leaves. This continued for several days or, in some seasons, even two or three weeks. This condition should not be confused with results of aphid infestation, nor should it be attributed to the retarding, if not actually injurious effects, of cold weather or frost.

In 1926 this form of foliage injury was unusually severe in the experimental orchard at Vincent, Washington County, in a plot of Rome Beauty trees sprayed in the "pink" with a 1-40 commercial liquid lime-sulfur solution. The trees all season thru failed to regain normal vigor and appearance. Even the fruit was injuriously affected in that, while it was no less abundant so far as the number of apples was concerned, it was comparatively smaller in size than the fruit of adjacent plots of trees of the same variety that were treated with other fungicides. In contrast was an adjoining plot of trees sprayed with a 3-50 dry lime-sulfur solution at the time the fruit buds were first showing pink tips. This plot showed no evidence of interruption to foliage development and the fruit was comparatively large and of better color and smoother finish. The same was true of dusted plots.

The lowest average percentage of sound, blotch-free apples from use of the entire group of standard lime-sulfur sprays applied at the critical period for control of blotch were 95.1, 96.2, 97.8, 98.8, and 99.0 percent. The check trees gave an average of only 11.3 percent of sound fruit for the same five-year period.

In addition to their efficiency in blotch prevention the lime-sulfur sprays gave fruit of superior color and finish as compared with that from the bordeaux plots in the same orchard.

Likewise, the two forms of lime-sulfur in the experiments in control of apple scab at Carpenter gave very high percentages of apples entirely free from scab. In effectiveness, they were fully equal to the 3-9-50 bordeaux mixture used in comparison and, in addition, gave fruit of very much better color and finer finish than did the copper sprays. The five- year average percentages of scab-free apples from the various lime-sulfur sprays were 84.7, 91.1, 91.9, 92.4, 96.3, 96.5, and 96.9. The five-year average of sound fruit on the unsprayed or check trees was 10.04 percent.

EFFECT ON SAN JOSE SCALE OF SUMMER SPRAYING WITH LIME-SULFUR

Another distinct advantage of the lime-sulfur sprays, as compared with bordeaux mixture, in these experiments, was their superiority, when used thruout each season on the same plots, in assisting in clearing San Jose scale from the orchard. In the orchard at Layman devoted to blotch prevention experiments there was, at the outset, a most serious infestation of San Jose scale. In spite of careful work in applying the delayed dormant sprays of strong lime-sulfur or oil emulsion, the scale persisted to show up annually for about three years on the bordeaux plots to a degree in many cases of incrustation of the apples at the calyx end. The fruit from the lime-sulfur plots from the beginning was free from scale.

BORDEAUX MIXTURE IN BLOTCH AND SCAB PREVENTION

In these experiments as effective control of apple blotch and apple scab was secured where the proportion of copper-sulfate was reduced almost to the point of elimination, yet, a generous proportion of fine, fresh hydrated lime used, as where the much stronger, or "standard", bordeaux was used.

There was practically no difference, so far as apple blotch prevention was concerned, in results from the use of bordeaux mixtures ranging from 3-9-50 down to ¾-2¼-50. The strongest, or 3-9-50, bordeaux gave a five-year average of 99.5 percent, and the weakest, or ¾-2¼-50, 98.6 percent of wholly sound apples. The five-year average of blotch-free fruit from the check, or untreated, trees was 11.3 percent. In color and finish the apples sprayed with the more dilute bordeaux were greatly superior to those sprayed with the stronger mixture, which considerably russeted and roughened the skins of the apples. However, even the bordeaux mixture of minimum strength did not produce as finely colored and smoothly finished apples as did the various lime-sulfur sprays.

In combating apple scab with bordeaux at Carpenter bordeaux formulas varying from 3-9-50 down to 1-5-50 proportions were used. The average percentages of sound apples were 83.9, for the 3-9-50 spray and 88.9 percent for the 1-5-50 and ½-2½-50 formulas.

It will be noted that five parts of hydrated lime to one of copper-sulfate in the bordeaux mixtures of minimum strength in the experiment did not detract from the fungicidal efficiency of the copper sprays.

LIME IN BLOTCH AND SCAB PREVENTION

It was noted early in these spraying tests that small proportions of copper-sulfate and large proportions of lime gave practically as efficient results in prevention of apple blotch and apple scab as did the 3-9-50 formula. In order to determine whether beneficial results in disease prevention were due to the very small amount of copper, the relatively heavy proportion of lime, or the combination of the two, copper-sulfate was wholly eliminated and the 9 pounds of lime retained and used in combination with 1¼ pounds of lead arsenate to each 50 gallons of water in the spray for a few plots.

On these plots in the experiments at Layman and Carpenter, a good grade of fresh hydrated lime seemed to possess considerable fungicidal efficiency. The earlier tests indicated that lime alone as a spray exerted somewhere from 25 to 40 percent efficiency as a fungicide, as compared with the usual formulas of bordeaux or lime-sulfur. However, as more was learned about the use of hydrated lime, and that there are a number of high grade brands which, when fresh from the hydrating plants, are superior to others, our continued tests with lime resulted in remarkably high percentages of control of both apple blotch and apple scab. In 1925 a 9-50 hydrated lime and arsenate of lead treatment thruout the spraying period resulted in from 80 to 95 percent of scab-free apples from old and young trees of Rome Beauty and Ensee varieties, while the check or untreated trees of the same variety gave but 2.5 percent of sound fruit. In other seasons lime alone, in both scab and blotch prevention tests, gave similar results. Regardless of these results we do not desire even to suggest that any orchardist substitute lime sprays for those of lime-sulfur solution, or dry lime-sulfur at the critical times for the control of scab and blotch.

THE USE OF DILUTE FORMULAS FOR AFTER-BLOOM SPRAYS

Dry lime-sulfur plus hydrated lime when used in the pink in the proportions of 3-5-50 and in 1½-5-50 or 2-5-50 for all sprays following the period of bloom, including the petal-fall application, gave excellent results in the five years under test. The senior author used this formula 4 years in his own private orchard of 20 acres, before suggesting it for consideration of others.

On Jonathan and Grimes apple trees in our own orchards, and at a few of the county experiment farms as well, a dry lime-sulfur hydrated lime spray of suitable concentration (3-5-50 or 4-5-50) was used in the pink of the fruit buds and only hydrated lime

(9-50 or 10-50) and lead arsenate for all of the after-bloom sprays, including that in the open calyx. These varieties are not likely to be attacked by apple scab and the fruit, under this very mild treatment, was as clear of the disease as where lime-sulfur was added to the lime for the summer sprays. This program of spraying succeeded even where such varieties as Rome, Stayman, and others more or less subject to scab were treated.

VARIETIES ESPECIALLY SUBJECT TO SPRAY INJURY

The fruit of some varieties of apples, of which Rome Beauty is representative, is comparatively resistant to spray injury in the form of russeting; but even Rome Beauty apples were roughened and dulled in color from the effect of copper sprays. On the other hand there are many varieties of apples very susceptible to russeting and even cracking and deformity by sprays. The Ben Davis type or family is especially notable for this weakness, copper sprays of the usual strength being very destructive when the earlier applications are coincident with cold or cool wet weather. The Ensee apple is extremely subject to serious russeting, and even to deformity, from action of copper sprays. Grimes Golden, too, is easily russeted—even the commercial liquid lime-sulfur spray, in certain seasons, causing more or less discoloration and roughening of the skin of the apples. The Golden Delicious is, perhaps, most susceptible of all of the commercial varieties of apples to injury by spraying.

However, with these easily injured varieties of apples in an orchard, it is safe to use the formulas for dry lime-sulfur and hydrated lime already suggested. Even Golden Delicious will come thru a full season's spraying without russeting.

Golden Delicious, like Jonathan, Grimes, and perhaps a few other kinds of apples, is not easily susceptible to infection by apple scab. And for such varieties it appears to be needless to apply strong sprays, especially after the blooming period.